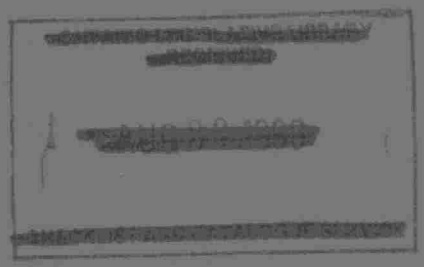
AIR QUALITY BALMERTOWN

Annual Report, 1979



Ministry of the Environment

Ontario

AIR QUALITY

BALMERTOWN

Annual Report, 1979

TECHNICAL SUPPORT SECTION
NORTHWESTERN REGION
ONTARIO MINISTRY OF THE ENVIRONMENT

July, 1980

CONTENTS

SUMMARY

Since 1971, the Ontario Ministry of the Environment has undertaken air quality assessment investigations in the vicinity of two gold mines at Balmertown.

Assessment of the crown condition and growth of trees in plots near the mines yielded inconclusive results. This study, terminated in 1979, provided evidence of a faster rate of decline and slower diameter growth in trees near the mines compared to trees at more distant sites, but the cause for this difference could not be established.

Air pollution injury to vegetation caused by arsenic or sulphur dioxide was absent in 1979. There was also very little damage to forest vegetation from insects or diseases.

Elevated arsenic concentrations persisted in vegetation near the mines, but were near normal in most of the townsite. Street tree sampling confirmed that there was significantly elevated arsenic in the northeast corner of the townsite. The arsenic content was very high in tailings area soil, but was only slightly above normal in grass from the same location. Arsenic levels in vegetables from Balmertown gardens were higher in 1979 than in 1978, and sometimes moderately exceeded the limit prescribed by the Canada Health Protection Branch. However, the Ministry considers Balmertown vegetables, if carefully washed before consumption, to be no threat to public health.

A moss exposure experiment and a snow sampling survey documented the continued presence of a small area of high arsenic and mercury deposition within about 250 metres of the roaster area at Campbell Red Lake Mines. This contamination was entirely confined to company property. The same surveys, together with suspended particulate measurements, showed that airborne arsenic and mercury concentrations were acceptable throughout most of the townsite.

Sulphur dioxide concentrations frequently exceeded Ministry regulations in Balmertown during 1979 but, unlike 1978, there was no vegetation damage observed. In early 1980, the ore roaster at Dickenson Mines was closed, and the company is considering the premanent termination of roasting operations. In the near future, Campbell will submit a report on the feasibility of meeting Ontario standards for sulphur dioxide.

INTRODUCTION

Since 1971, the Ontario Ministry of the Environment has undertaken air quality studies in the vicinity of two gold mines at Balmertown. Campbell Red Lake Mines Limited and Dickenson Mines Limited both employ ore roasting processes which emit significant quantities of arsenic trioxide and sulphur dioxide. In recent years, both firms have commissioned pollution control equipment capable of reducing atmospheric emissions of arsenic from several metric tons to less than 50 kilograms per day. For technological and economic reasons, the control of sulphur dioxide has not yet been possible. The discharge rate of this pollutant was estimated in 1979 to be 20 metric tons daily for Campbell and 11 tons for Dickenson.

The Ministry's 1979 air quality assessment programme at Balmertown continued along similar lines described in earlier reports, the most recent of which was issued in 1979 (1).

VEGETATION AND SOIL ASSESSMENT

FOREST AREA

Observation Plots

Crown conditions and tree growth were assessed at 11 of the 16 trembling aspen (*Populus tremuloides*) plots established in 1974 (Figure 1). The procedure for evaluating tree crowns was described in an earlier report (2).

A comparison of crown conditions in 1974 and 1979 appears in Table 1. The data show that the highest incidence of dieback, rate of decline, and mortality occurred in plots 1 and 5, near Campbell Red Lake Mines. However, this area is frequently disturbed by periodic tree felling and road construction and, consequently, an assessment of factors affecting tree health is

difficult. The condition of trees in other plots was similar to that for the controls, and some crown decline was noted at all sites. Tree diameter growth rates (Table 2) were higher in control plots than in most plots near the mines, but there was great variability and no clear trend to indicate an air pollution effect. The unusual growth rate at plot 6 was attributed to a release effect caused by the removal of competing trees around the study plot. Height growth from 1974 to 1979 also showed much variation from plot to plot, and no differences were observed that could be related to distance from either mine.

Because of the many possible factors affecting tree growth and health, and because of the frequent significant disturbances in the study area, the Ministry's plot assessment programme has yielded inconclusive results. For these reasons, this part of our investigation was terminated in 1979.

Vegetation Injury

In contrast to 1978, there was no sulphur dioxide vegetation damage found in the Balmertown area in the 1979 growing season. As discussed later in this report, there were fewer potentially injurious sulphur dioxide fumigations in 1979 than in 1978. There was no evidence of arsenic injury to vegetation.

The insect damage situation also improved in 1979, with no significant outbreak of forest tent caterpillars or other noteworthy insect or disease problems.

Chemical Analysis

Triplicate samples of trembling aspen foliage were collected from 24 points around the mines (Figure 1) and at two control locations several kilometres to the south. Because earlier data showed that arsenic levels in Balmertown soils were relatively stable from year to year, no soil sampling was undertaken in 1979. Foliage samples were analysed for arsenic at the Ministry's Thunder Bay laboratory. Sampling, sample processing and analytical procedures were the same as those described in our 1977 report (2).

Arsenic concentrations in trembling aspen foliage, plotted in Figure 2, were significantly elevated in the area between the two mines. The highest levels were nearly 70 times the values for the control samples, and about 9 times the maximum of the range considered normal for Ontario. Data from the past 2 years demonstrate that periodic emissions of arsenic have resulted in a small, but persistent, zone of contamination near the mines. Roaster start-up or shutdown procedures, occasional failure of pollution control equipment, or the dispersion of windblown waste materials might all contribute to the problem. Despite the few high readings, average arsenic levels in the area were much reduced from the pre-control years in the early 1970's (Table 3). In addition, foliar arsenic concentrations in or near the townsite area were within or only slightly above the normal range.

TAILINGS AREA

Forage (grass) and surface soil (0-5 cm in depth) were sampled from three locations in an area near the junction of Highway 105 and the Balmertown turn-off, where Campbell Red Lake Mines had recently completed a tailings re-vegetation project.

The soil contained approximately 500 to 1000 µg/g arsenic (micrograms of arsenic per gram of dried soil) and the forage about 8 to 30 µg/g arsenic. This finding indicates that while tailings soil contains high levels of arsenic, very little of it is translocated to the above-ground parts of vegetation in the area.

Antimony, as expected, was present at levels in the 50 to 90 µg/g range in tailings soil, and less than 1 µg/g in the vegetation samples. Mercury was very low (less than 1 µg/g) in both soil and vegetation.

PLANTED ROADSIDE TREES

Foliage from white elm (*Ulmus americana*) and Manitoba maple (*Acer negundo*) from two locations in residential Balmertown were analysed for arsenic. The results, in Table 4, show that arsenic concentrations were acceptable at one site (Fifth and Mine) but unsatisfactory at the other (Dickenson and Mine), where elevated arsenic was also found in trembling aspen (see data for site 19, Figure 2). At the Dickenson and Mine location, the arsenic concentration was nearly three times higher in foliage on the sides of trees facing the mines than in foliage from the opposite sides, thereby implicating the mines as the emission source.

VEGETABLE GARDENS

Several kinds of vegetables were sampled from two residential gardens in Balmertown and from a control garden in Red Lake. Surface soil from lawns and gardens was also obtained at the same locations. Sampling and sample processing procedures were similar to those for other vegetation, except that garden vegetables were washed in tap water before being dried, ground, and submitted for arsenic and mercury analysis.

The data, in Table 5, reveal that the arsenic content in lawn and garden soil showed little change from earlier years, but that arsenic in vegetables increased in 1979 from the generally satisfactory situation recorded in 1977 and 1978. Arsenic in beet leaves and lettuce leaves from one of the two gardens sampled in Balmertown exceeded the maximum acceptable limit (1 µg/g arsenic, fresh weight) established by the Health Protection Branch, Canada Department of Health and Welfare. Arsenic in potato tubers and beet roots was below the limit. Since the federal limit contains a substantial safety factor, the consumption of Balmertown garden produce is not considered a hazard, if vegetables are first washed to remove soil particles.

Mercury concentrations in all garden vegetables were consistently well below the recommended guideline of 0.05 µg/g, fresh weight, set by the World Health Organization and the United Nations Food and Agriculture Organization.

MOSS EXPOSURE

To follow up experiments conducted in 1977 (2) and 1978 (1), samples of *Sphagnum* moss were exposed for 42 days (August 22 to October 3) at 28 sites around the mines and at two control locations. The samples, analysed for arsenic and mercury in the normal manner, demonstrated that airborne arsenic was present in significant concentrations near the two gold mines (Figure 3). The area where elevated values occurred was larger in 1979 than that found in 1978 during a study of the same duration. Arsenic concentrations for the exposed and unexposed controls were consistently below 10 µg/g, and hence well below the highest levels recorded in the study area.

Mercury concentrations in moss were all near background levels, except at three sites near Campbell Red Lake. The highest value of 5 µg/g, compared with 0.2 µg/g for the control, was recorded near Campbell's refinery building.

SNOW SAMPLING

Snow samples collected in 1978 demonstrated the presence of a small area of significantly elevated arsenic and mercury near Campbell Red Lake's roaster (1). This survey was repeated in February, 1979, using standard Ministry sampling procedures. Duplicate samples from 24 sites, plus controls (Figure 4), were submitted for arsenic and mercury analysis to the Ministry's Thunder Bay laboratory, and for sulphate determination to the central laboratory in Toronto.

The data are summarized in Table 6 and arsenic values are plotted in Figure 5. Arsenic contamination persisted in 1979 near Campbell Red Lake, though concentrations were lower than those in 1978. Values significantly above background were found throughout much of the survey area. The arsenic content in snow from the townsite area was only slightly above normal. Mercury was again elevated in the immediate vicinity of Campbell's roaster, but normal elsewhere. Sulphate levels were also well above background concentrations at several sites, most noteably those closest to Campbell. Fugitive emissions from Campbell are suspected as the source of elevated arsenic and mercury in the immediate vicinity of the ore processing plant.

AIR QUALITY MONITORING

SUSPENDED PARTICULATE MATTER

Campbell Red Lake Mines operated a high-volume sampler for 24 hours every sixth day at the Balmertown Improvement District Office. The sampling method is described in an earlier report (1). Analysis of filters for arsenic was undertaken by the company's consultants.

The 1979 data, for 47 samples, are reported in Table 7. There were two excursions above Ontario's air quality objective of 120 $\mu g/m^3$ (micrograms of total suspended particulate matter per cubic metre of air). Highest average values were associated with prevailing wind from the south and west (upwind of the mines) and lowest concentrations with wind from the north and east (downwind of the mines). The highest arsenic level, 155 ng/m^3 (nanograms of arsenic per cubic metre of air) was well below the 5000 ng/m^3 permitted under Ontario regulations. Many arsenic values were below the detection limit. There was no relationship between arsenic concentration and prevailing wind direction.

The high volume sampler data clearly showed that in the southern part of Balmertown, mine emissions made no significant contribution to levels of total supended particulate matter or to arsenic in suspended particulate.

SULPHUR DIOXIDE

Sulphur dioxide (SO_2) has many well-known adverse effects on human health, vegetation and property. In Balmertown, the ore roasting operations at the two mines are the only significant local sources of this pollutant.

The Ministry operates a continuous SO_2 monitor (TECO model 43) at Balmertown Public School, together with meteorological equipment to record wind direction and wind speed. The SO_2 readings for 1979 are summarized in Table 8 and Figure 6. During the year, the Ontario hourly objective of 0.25 ppm (parts of SO_2 per million parts of air, by volume) was exceeded 153 times, compared with 133 in 1978. The maximum hourly average of 0.70 ppm (0.75 ppm in 1978) was nearly three times the acceptable limit. There were also 8 violations (9 in 1978) of the 24-hour objective. The annual average of 0.016 ppm was, however, below the maximum acceptable concentration of 0.020 ppm.

The significance of SO_2 levels in relation to possible vegetation injury was assessed through the determination of the number and intensity of "potentially injurious fumigations" (PIF). In the PIF system (3), a value of 100 is assigned to any fumigation in which average SO_2 levels exceed 0.95 ppm for 1 hour, 0.55 for 2 hours, 0.35 for 4 hours or 0.25 for 8 hours during daylight periods in the growing season. Intensity values exceeding 100 are considered potentially injurious to sensitive vegetation. In 1979 at Balmertown, there were only three potentially injurious fumigations (six in 1978) and the maximum intensity for the three fumigations was only 128, well below the 172 recorded in 1978. Because of the infrequency and weakness of the fumigations in 1979, no visible injury to vegetation was observed.

An analysis of SO_2 readings and wind direction, in Table 9, shows that virtually all the SO_2 recorded at Balmertown Public School was associated with wind from Campbell's roaster stack. Campbell was also determined to be the primary or only source responsible for the three potentially injurious fumigations during the year.

At concentrations now being measured, sulphur dioxide emissions from the mines are not considered a threat to the health of Balmertown residents. Under the worst conditions, mildly disagreeable odours might be experienced for short periods of time. However, emissions do exceed Ontario regulations and, consequently, may result in occasional injury to vegetation. In early 1980, Dickenson suspended roasting operations pending development of ore processing techiques that will, if successful, eliminate the need to roast. Campbell has been requested by the Ministry to submit a feasibility study on the control of SO_2 emissions to meet Ministry standards.

ACKNOWLEDGEMENT

The Ministry wishes to thank Campbell Red Lake Mines Limited for providing the data on suspended particulate matter in Balmertown.

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1. Ontario Ministry of the Environment. 1979. Air quality, Balmertown. Annual Report, 1978.

2. Ontario Ministry of the Environment. 1978. Air quality, Balmertown. Annual Reprot, 1977.

3. Dreisinger, B. R. 1967. The impact of sulphur dioxide pollution on crops and forests. Pollution and Our Environment, Conference Background Papers, Vol. I, Montreal, Canadian Council of Resource Ministers. Paper A4-2-1.

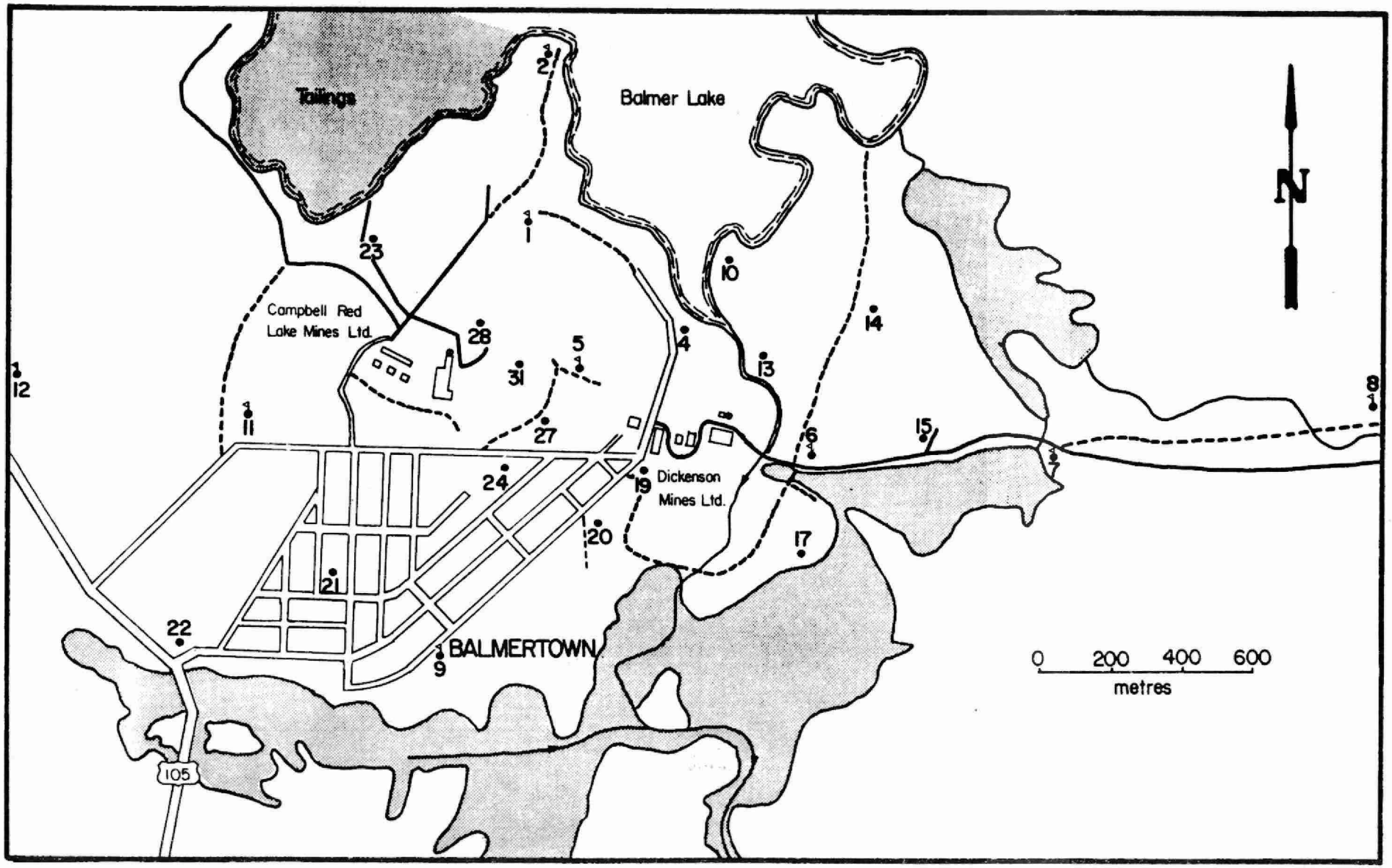

Figure 1. Vegetation sampling sites, 1979. (1 Observation plots)

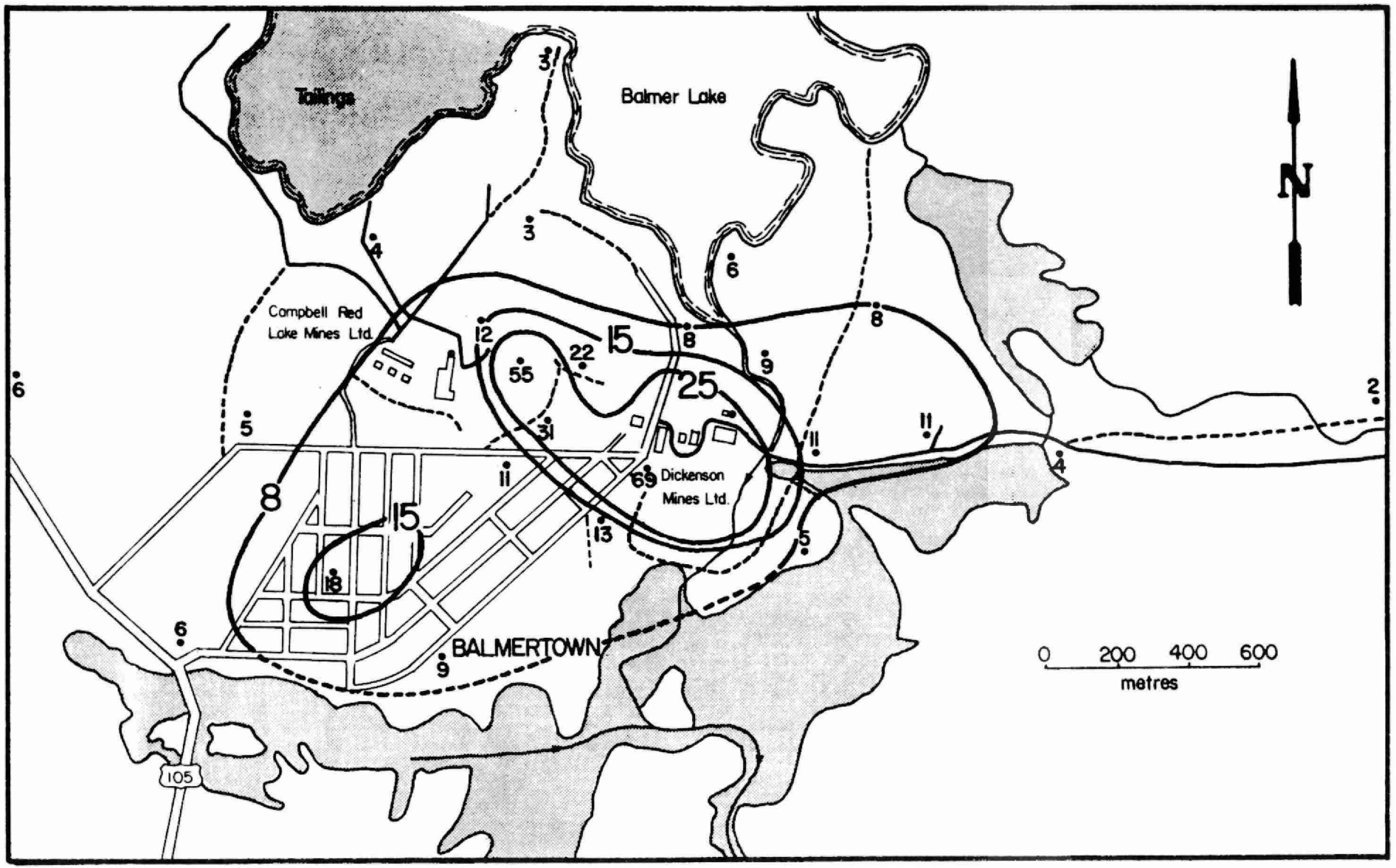

Figure 2. Average arsenic levels (µg/g, dry weight) in unwashed trembling aspen foliage, August, 1979.

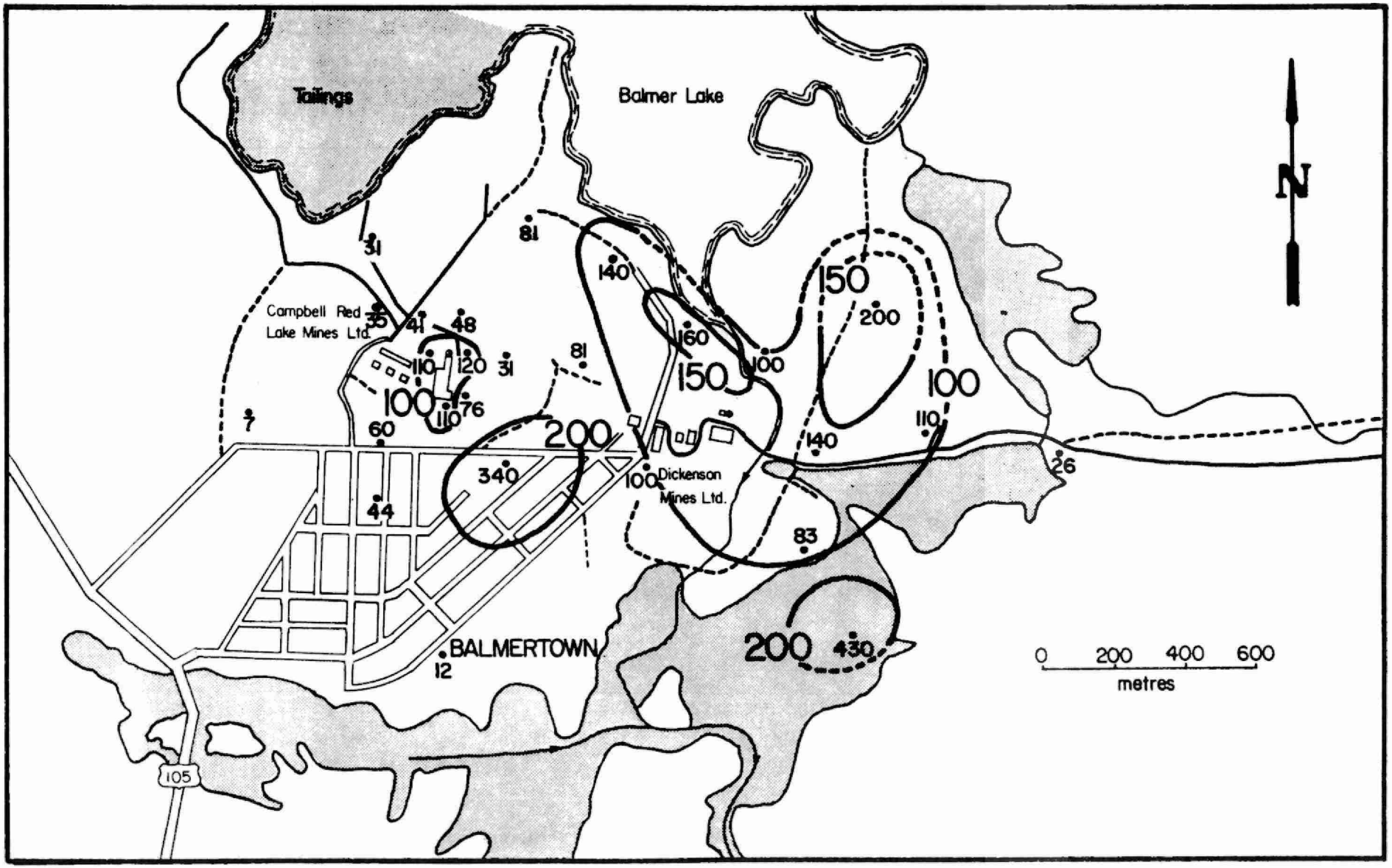

Figure 3. Arsenic (µg/g, dry weight) in moss exposed from August 22 to October 3, 1979.

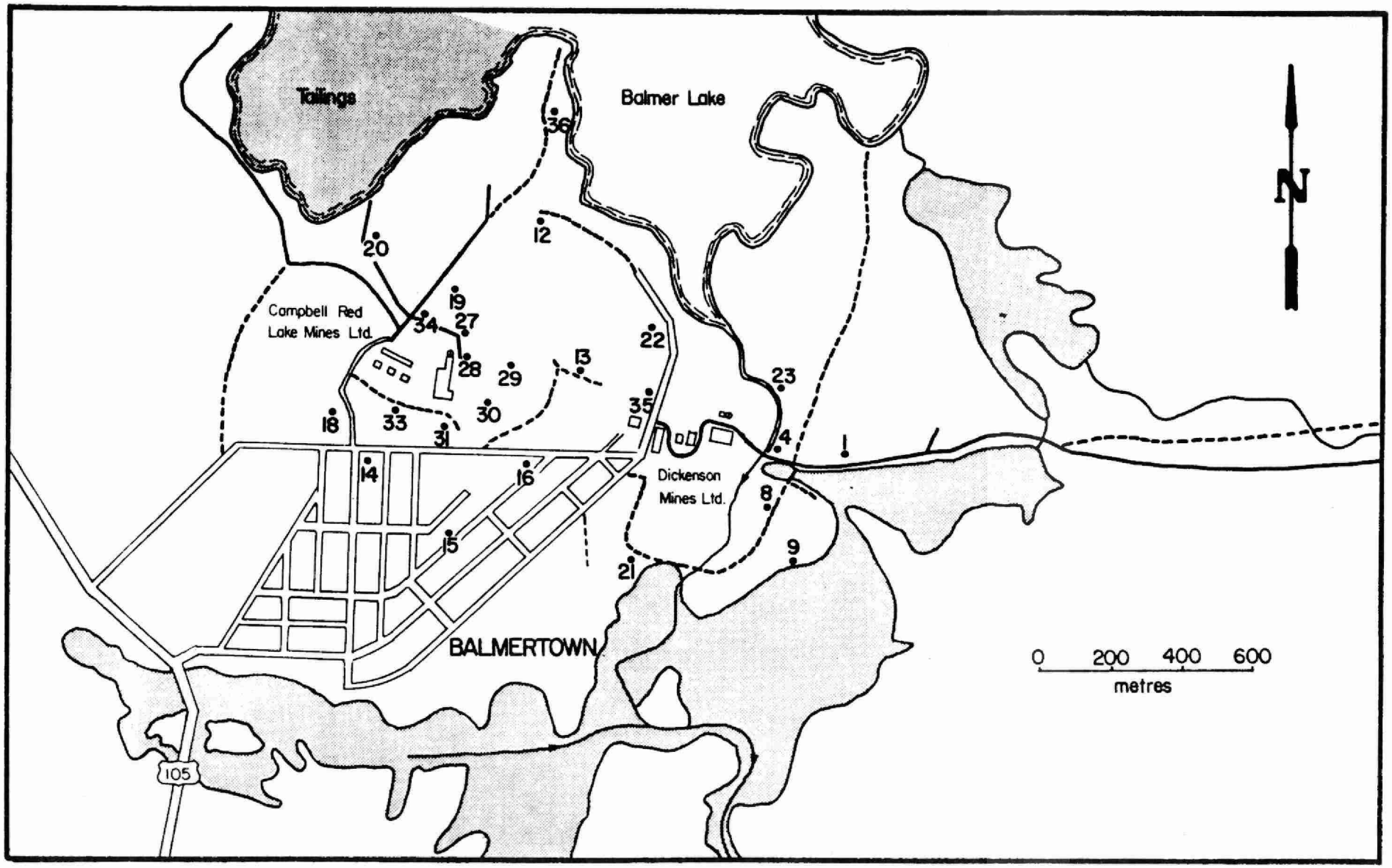

Figure 4. Snow sampling sites, 1979.

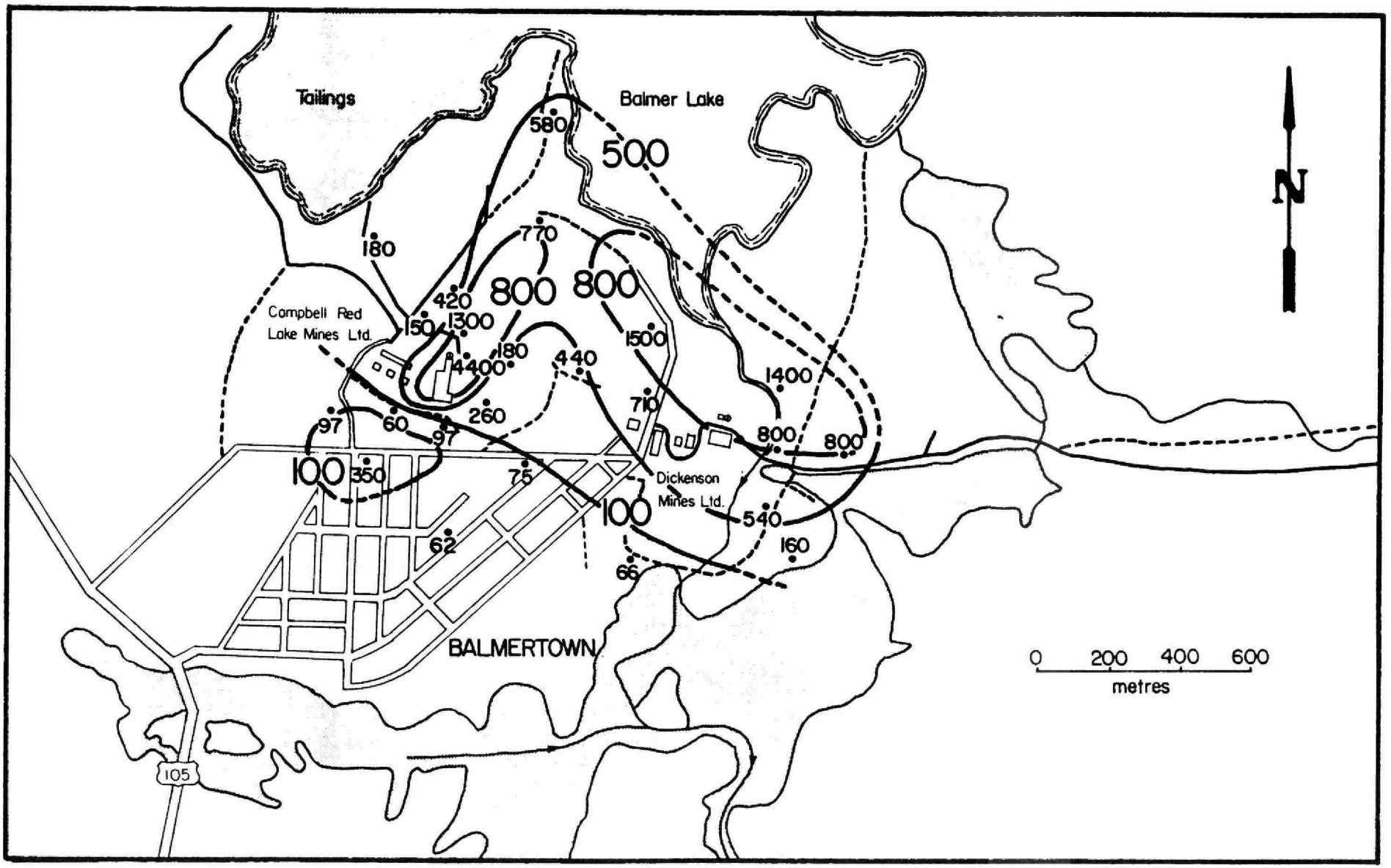

Figure 5. Arsenic concentrations (µg/l) in snow, February, 1979.

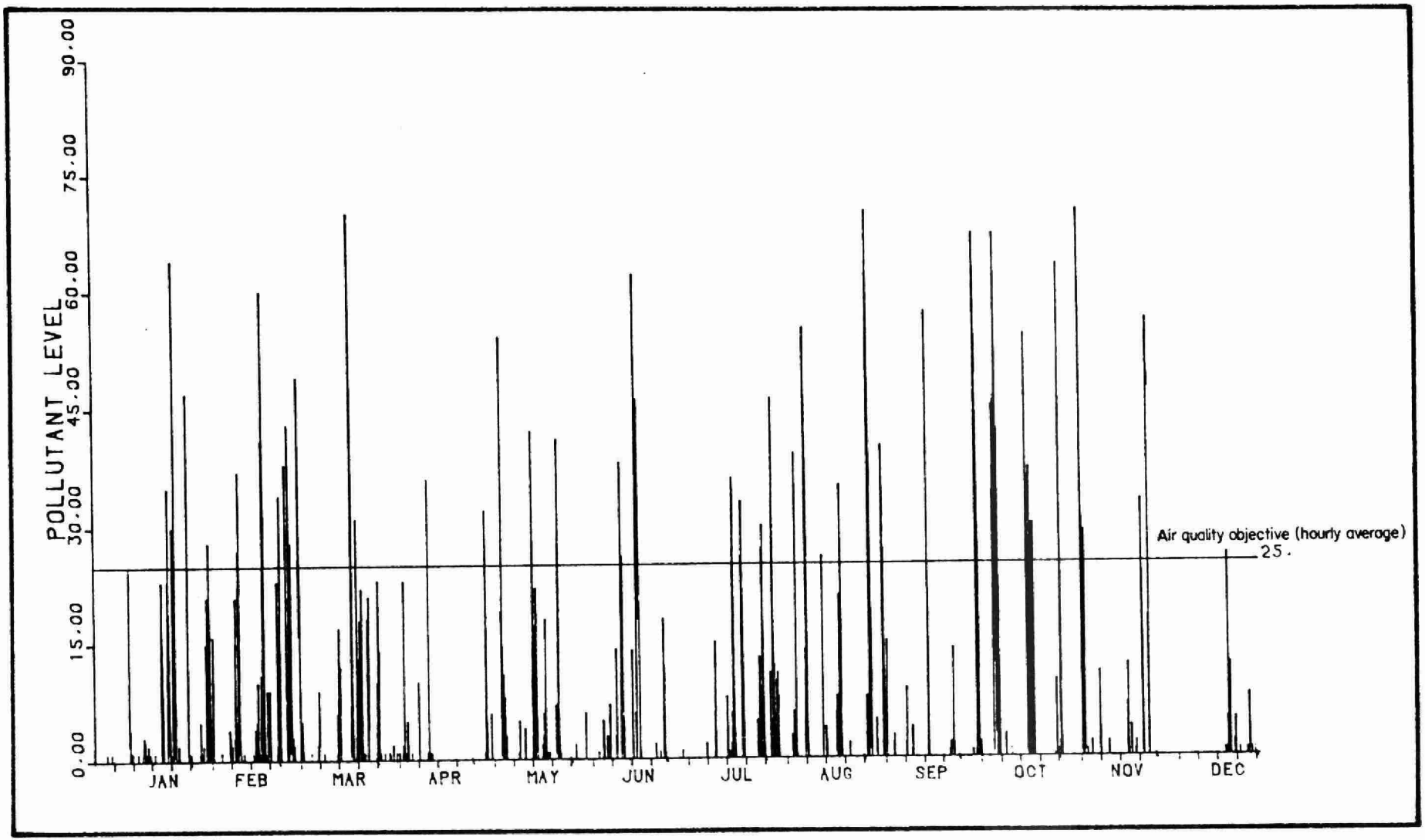

Figure 6. Hourly average sulphur dioxide concentrations (parts per hundred million), station 61010, Balmertown, 1979.

TABLE 1. Crown condition of trees in observation plots, July, 1974 and August, 1979.

Plot	Distance (metres) and direction from Campbell	Dickenson	Number of trees: Apparently healthy 74	79	Slight dieback 74	79	Advanced dieback 74	79	Dead 74	79
1	0.4 NNE	0.8 NW	20	8		2		1		9
2	0.9 NNE	1.2 NNW	20	15				1		4
5	0.4 E	0.5 W	12	2	7	3	1	5		10
6	0.7 ESE	0.3 ESE	20	19		1				4[a]
7	1.5 E	1.0 E	15	13	4	1	1	2		
8	2.7 E	1.9 E	19	10	1	4		3		3
9	0.7 S	0.8 SW	18	13	1	1	1	1		5
11	0.6 WSW	1.4 W	16	14	3	3	1			3
12	1.4 W	2.2 W	17	12	3	1		3		3
15	27.2 SE (control)		20	13		4	1			2
16	12.5 S (control)		19	12	1	1		2		5

[a] one tree felled

TABLE 2. Changes in crown condition and stem diameters of trees in observation plots from 1973 and 1974 to 1979.

Plot	Crown condition (1974 to 1979): Unchanged	Improved	Declined	Dbh (cm)[a]: 1973	1979	Growth: cm	%
1	8		12	4.5	4.8	0.3	7
2	15		5	5.6	5.8	0.2	4
5	3		17	5.1	5.2	0.1	2
6	19		1[b]	2.7	3.6	0.9	33
7	13	1	6	6.1	6.8	0.7	11
8	10		10	9.1	9.6	0.5	5
9	13		7	6.1	6.4	0.3	5
11	14	1	5	5.7	6.2	0.5	9
12	13		7	7.8	8.1	0.3	4
15 (control)	13		7	4.5	5.1	0.6	13
16 (control)	12		8	4.1	4.7	0.6	15

[a] diameter, breast height, in centimetres

[b] one tree felled

TABLE 3. Comparison between arsenic content (µg/g, dry weight) of unwashed trembling aspen foliage for the period 1972 to 1979.

Site	1972	1973	1974	1975	1976	1977	1978	1979
1			26	31	10	5	4	3
2			22	26	6	12	9	3
5	160	550	29	33	18	12	9	22
6	78	400	200	260	50	8	33	11
7	21	81	43	29	5	4	20	4
8			14	18	4	2	6	2
9	260	410	19	6	6	5	5	9
11	98	110	10	7	2	4	2	5
12	27	41	9	9	4	3	3	6
Controls	< 1	8	3	2	< 1	< 1	< 1	< 1

TABLE 4. Comparison between average arsenic content (µg/g, dry weight)[a] in unwashed foliage from planted roadside Manitoba maple and white elm trees, Balmertown, 1973 to 1979.

Year	Side of tree	Dickenson & Mine Road	Balmertown public school	Fifth St. & Mine Road	Controls
1973	Facing	504	734	352	19
	Away	323	432	202	25
1974	Facing	70	36	20	4
	Away	31	21	12	
1975	Facing	138	76	34	4
	Away	58	46	18	
1976	Facing	18	12	20	2
	Away	18	9	11	
1977	Facing	13	6	8	<1
	Away	16	5	8	
1978	Facing	5	5	5	<1
	Away	4	4	3	
1979	Facing	69		8	2
	Away	22		7	

[a]values for 1973 and 1974 represent single samples, and those for 1975-1979 are averages of triplicate samples

TABLE 5. Comparison between average arsenic levels (µg/g, dry weight)[a] in washed vegetation and surface soil (0-5 cm) from three[b] Balmertown gardens, 1973 to 1979.

Sample	Balmertown							Red Lake (control)						
	1973	1974	1975	1976	1977	1978	1979	1973	1974	1975	1976	1977	1978	1979
Potato - leaves		18	24	15	9	6	37		4	2	2	2	1	5
- tubers		2	2	2	<1	<1	<1		<1	<1	<1	<1	<1	<1
Beet - leaves	180	8	8	7	7	2	13	8	<1	<1	<1	<1	<1	1
- roots	40	3	9	4	6	3	8	2	<1	<1	<1	<1	<1	<1
Lettuce - leaves	140	9	18	12	7	9	12		2	<1	<1	<1	1	1
Soil - garden		160	150	60	360	120	93		10	10	8	7	6	6
- lawn		570	450	210	340	280	270		14	10	9	8	11	24

[a] values for 1973 and 1974 represent single samples, and those for 1975-1979 are averages of triplicate samples

[b] two gardens in 1979

TABLE 6. Average concentrations of arsenic, mercury and sulphate in meltwater from snow samples collected in Balmertown in January, 1978 and February, 1979.

Site	Arsenic (µg/l) 1978	Arsenic (µg/l) 1979	Mercury (ng/l) 1978	Mercury (ng/l) 1979	Sulphate (mg/l) 1979
1	180	800	<50	50	0.8
4	60	800	60	540	1.2
8	60	540	<50	260	0.8
9	70	160	40	240	0.6
12	320	770	2100	460	0.8
13	450	440	2800	460	1.0
14	100	350	50	<50	0.9
15	60	62	<50	100	1.8
16	60	74	60	90	1.2
18	80	97	200	320	0.8
19	130	420	1200	140	0.7
20	140	180	980	60	0.6
21	40	66	60	<50	0.8
22	100	1500	1200	200	1.0
23	80	1400	130	430	1.2
27	300	1300	9400	23000	2.4
28	31000	4400	1000000	92000	5.3
29	320	180	4500	3900	1.0
30	80	260	430	360	0.8
31	140	97	490	300	0.9
32	30	-	50	-	-
33	100	60	200	760	0.8
34	100	150	1500	430	0.8
35	-	710	-	390	1.2
36	-	580	-	200	0.7
controls	<10	22	<50	70	0.4
normal background	<25		<500		<5.0

TABLE 7. Suspended particulate matter ($\mu g/m^3$), Balmertown, 1979.[a]

Date	Concentrations		Wind[c]	Date	Concentrations		Wind
	Total	Arsenic[b]			Total	Arsenic	
Jan 4	-	-	WSW	Jul 2	90	18	SSE
10	< 1	6	WSW	8	30	6	-
16	4	< 5	-	14	16	< 5	-
22	4	56	-	20	15	7	SW
28	2	14	-	26	19	< 5	SVRL
Feb 3	5	7	-	Aug 1	-	-	SSW
9	2	< 5	SVRL				
15	4	< 5	NNW	Sep 24	105	12	W
21	5	< 5	N				
27	-	< 5	N	Oct 1	-	-	-
				12	18	9	SVRL
Mar 4	4	9	C	18	13	< 5	SE
16	12	10	ESE	24	6	< 5	NNE
22	8	< 5	SSW	30	6	54	NE
29	6	< 5	ESE				
				Nov 5	9	7	W
Apr 3	8	< 5	E	11	11	< 5	SSE
9	34	6	C	17	< 1	7	ESE
15	53	< 5	SW	23	-	-	NNE
21	3	< 5	WSW	29	< 1	10	WNW
27	9	< 5	N				
				Dec 5	< 1	< 5	NNW
May 3	17	< 5	W	11	1	< 5	N
9	52	24	NNE	17	< 1	20	ESE
15	10	6	SSW	23	< 1	8	C
21	75	155	SSW	29	6	28	C
27	87	19	SVRL[d]				
Jun 3	<u>125</u>[e]	16	W				
8	<u>97</u>	40	N				
14	<u>139</u>	10	SW				
20	<u>40</u>	151	ESE				
26	76	9	WNW				

[a] data from Campbell Red Lake Mines Limited

[b] nanograms per cubic metre (1000 nanograms = 1 microgram)

[c] prevailing wind direction recorded at station 61010

[d] several

[e] values above the Ontario air quality objective (120 $\mu g/m^3$) are underlined

TABLE 8. Distribution of sulphur dioxide readings (pphm[a], hourly averages) at station 61010, Balmertown, 1979.

Month	Days of data	No. of readings for concentrations of: 0-5	6-10	11-15	16-25	26-39	>39	Maximum values: Hour	Day
Jan	27	609	5	4	12	2	3	64	9
Feb	27	548	21	14	15	9	5	60	18
Mar	17	459	28	8	18	14	6	70	12
Apr	17	374	1	0	1	1	0	36	2
May	23	558	16	7	15	3	3	54	9
Jun	30	655	9	8	10	10	7	62	25
Jul	31	708	7	10	11	7	0	36	9
Aug	31	690	18	11	6	4	5	55	12
Sep	28	621	4	3	5	8	11	70	20
Oct	30	613	7	6	17	24	15	67	21
Nov	23	531	1	6	3	6	9	70	9
Dec	12	274	4	1	0	1	0	26	2
YEAR	296	6640	121	78	113	89	64	70	25

[a]parts per hundred million, by volume

TABLE 9. Directional distribution of hourly readings of sulphur dioxide in 1979 at station 61010, Balmertown.

Wind[a]		Average hourly sulphur dioxide concentration (pphm[b])
Direction	% frequency	
N	5.5	13
NNE	4.5	2
NE	2.8	4
ENE	2.5	1
E	3.1	<1
ESE	4.9	<1
SE	5.1	0
SSE	3.8	0
S	1.9	0
SSW	3.6	<1
SW	4.9	<1
WSW	5.8	<1
W	2.9	<1
WNW	4.5	<1
NW	4.1	2
NNW	3.8	10
Calm	36.2	1

[a]measured 10 m above ground at station 61010

[b]parts per hundred million

ONTARIO

TERMINAL STREAM: MAGNETAWAN

DATE	ISSUED TO